NOAA FISHERIES

SWFSC

4.2 Overview of HMS Assessment:

Does the Center apply a suitable scientific/technical approach to fishery stock assessment modeling?

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Fisheries Resources Division

Southwest Fisheries Science Center

July 29, 2014

Outline

1. HMS assessments
2. Assessment Process
3. Data
4. Models
5. Examples of Assessments
6. Modeling issues
7. Improvements (what to do and what we have done)
8. Conclusions

and Species Assessed by SWFSC NOAA

N.P. Albacore tuna	Swordfish	N.P. Blue shark
P. Bluefin tuna	Striped Marlin	Mako shark
	Blue Marlin	Thresher shark
ISC SWFSC lead assessments	*ISC PIFSC lead*	*year? Non-ISC*

Recent Stock Assessments	year	type	collaborators
Mako shark	*est.2015*	*1st assessment*	*ISC, IATTC, SPC*
Blue Shark	2014	Benchmark	ISC, IATTC, SPC
Albacore tuna	2014	Benchmark	ISC, IATTC
Bluefin tuna	2014	Update	ISC, IATTC
Blue shark	2013	1st assessment	ISC, IATTC, SPC
Bluefin tuna	2013	Benchmark	ISC, IATTC
Blue Marlin	2012	Benchmark	ISC, IATTC
Albacore tuna	2011	Benchmark	ISC, IATTC
Striped Marlin	2011	Benchmark	ISC, IATTC

Key Features of the HMS Assessment Process

HMS assessments conducted by several different science providers (ISC, IATTC, SPC)
sometimes collaboratively
SWFSC performs assessments under the ISC and acts as reviewer for IATTC, SPC

Internal partners usually include PIFSC (either data analysis or assessment modeling)
may include other Science Centers (collaborators/reviewers)
External partners include member countries, RFMO scientists and academics

ISC assessments are consensus (SPC, IATTC in general are not)

ISC has no formal process of benchmark vs. update

ISC moving to providing new assessments every 3 years

In general control rules and BRP's not yet in place

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Timeline of "*Typical*" ISC Assessment

To complete a benchmark stock assessment typically takes 3 meetings & 1 year

*provide catch/effort
*size data

← submit data →

Data through 2006
final data
submissions

May 1 -
distribute assessment

November 2008 ⇨ **December 2008** ⇨ **January 2009** ⇨ **February 2009** ⇨ **March 2009** ⇨ **April 2009** ⇨ **May 2009**

Billfish WG
Special Session

*Stock Structure
Scenario:
1) Single NP stock
2) 2-Stock (Ichinokawa)

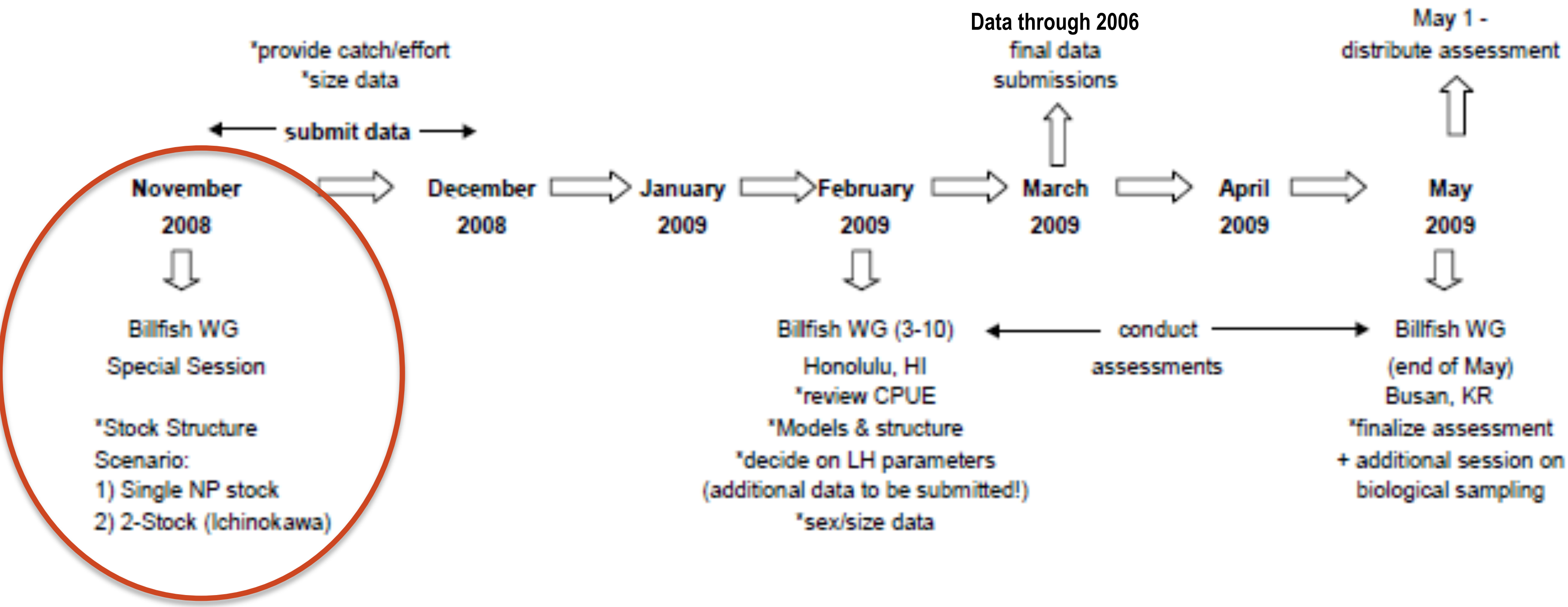
Billfish WG (3-10)
Honolulu, HI
*review CPUE
*Models & structure
*decide on LH parameters
(additional data to be submitted!)
*sex/size data

← conduct assessments →

Billfish WG
(end of May)
Busan, KR
*finalize assessment
+ additional session on
biological sampling

Timeline of "*Typical*" ISC Assessment

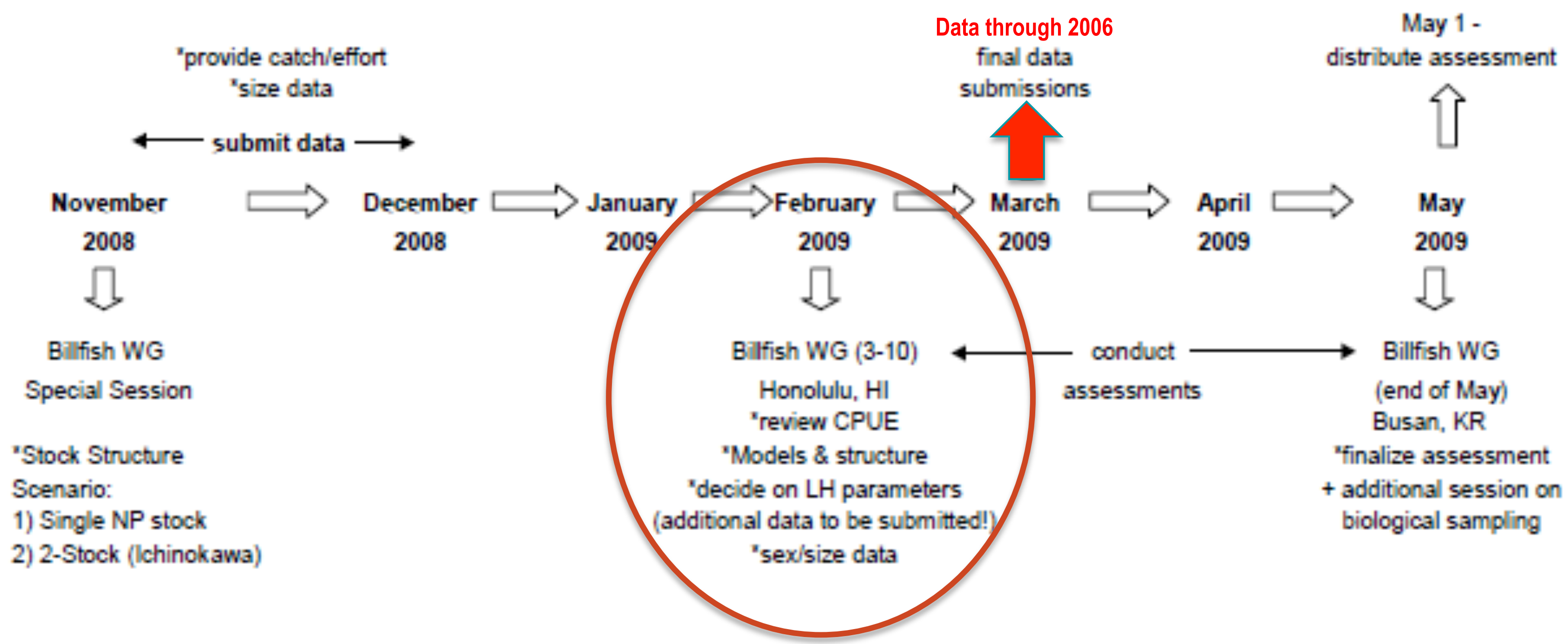
To complete a benchmark stock assessment typically takes 3 meetings & 1 year



How to structure & analyze the data

Timeline of "*Typical*" ISC Assessment

To complete a benchmark stock assessment typically takes 3 meetings & 1 year

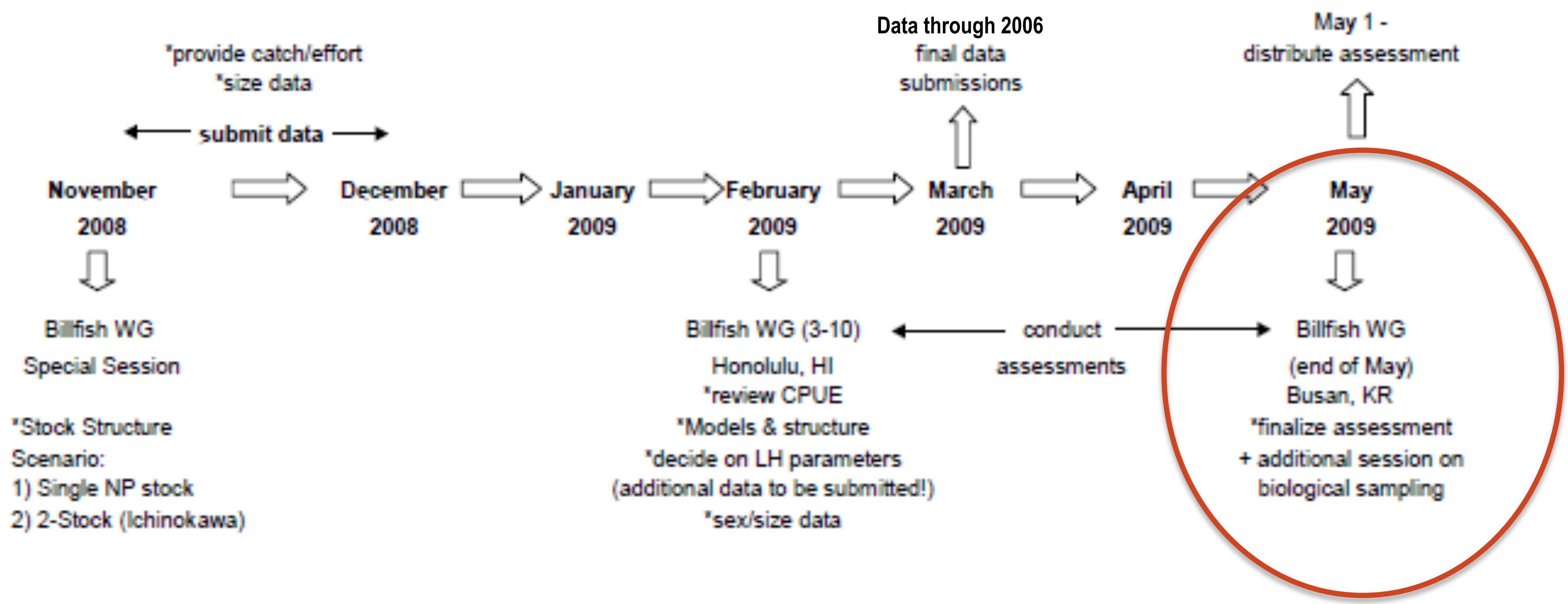


Review the data and analyses

Timeline of "*Typical*" ISC Assessment

To complete a benchmark stock assessment typically takes 3 meetings & 1 year

Data is usually 2-3 years old by the time it is finalized



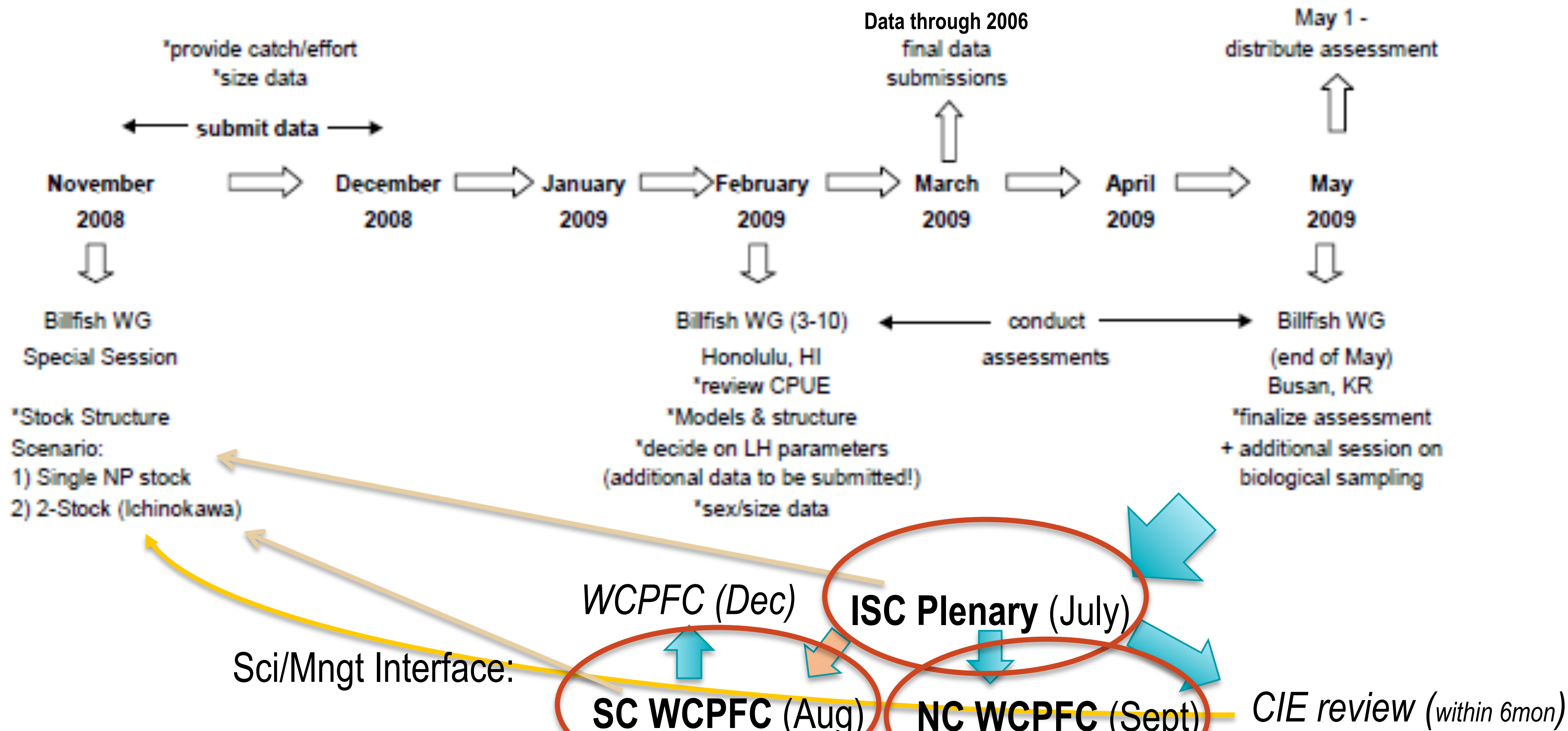
Timeline of “*Typical*” ISC Assessment

To complete a benchmark stock assessment typically takes 3 meetings & 1 year

Data is usually 3+ years old by the time it reaches decision makers

……………………………*Meetings are a big time sink*

7 steps to complete assessment



HMS Stock Assessment Complexity

Biology is complex due to the large spatial boundaries of the stocks
(e.g. spatial variability in age/sex, growth, timing of recruitment, and they MOVE)

Fisheries are complex. Fisheries cover large areas & also MOVE.
Spatial patterns change both horizontally and vertically. Targets of the fisheries change as abundance of potential targets change and with the development of new gears.

Process is complex. Assessments are consensus-based science. Can become political with outcomes that are not acceptable to some participants

Typical HMS Data availability for assessment

Describes a fleet

Catch- by fleet.

Composition- both weight and length available (usually no age composition).

Composition more available in the recent period than in earlier periods.

For some species and stocks, composition can be exotic like boxes.

Indices of abundance- CPUE of fisheries primarily Japanese Longline..

Research Projects- Primarily life history data used to specify parameters or as likelihood component used to estimate things like growth. Soft knowledge used to help guide the structure of data/models (e.g. limited tagging)

Data Issues

By fleet

For some stocks catch may be incomplete (discard, non-reporting, aggregate reporting and even plain lying)

For many stocks/fleets composition data often missing entirely or for periods of time

Trends in abundance come from fishery CPUE. Standardization, spatial coverage

Incomplete knowledge of life history (missing or sex/area/time-specific)

Complex biological information missing (e.g. movement rates).

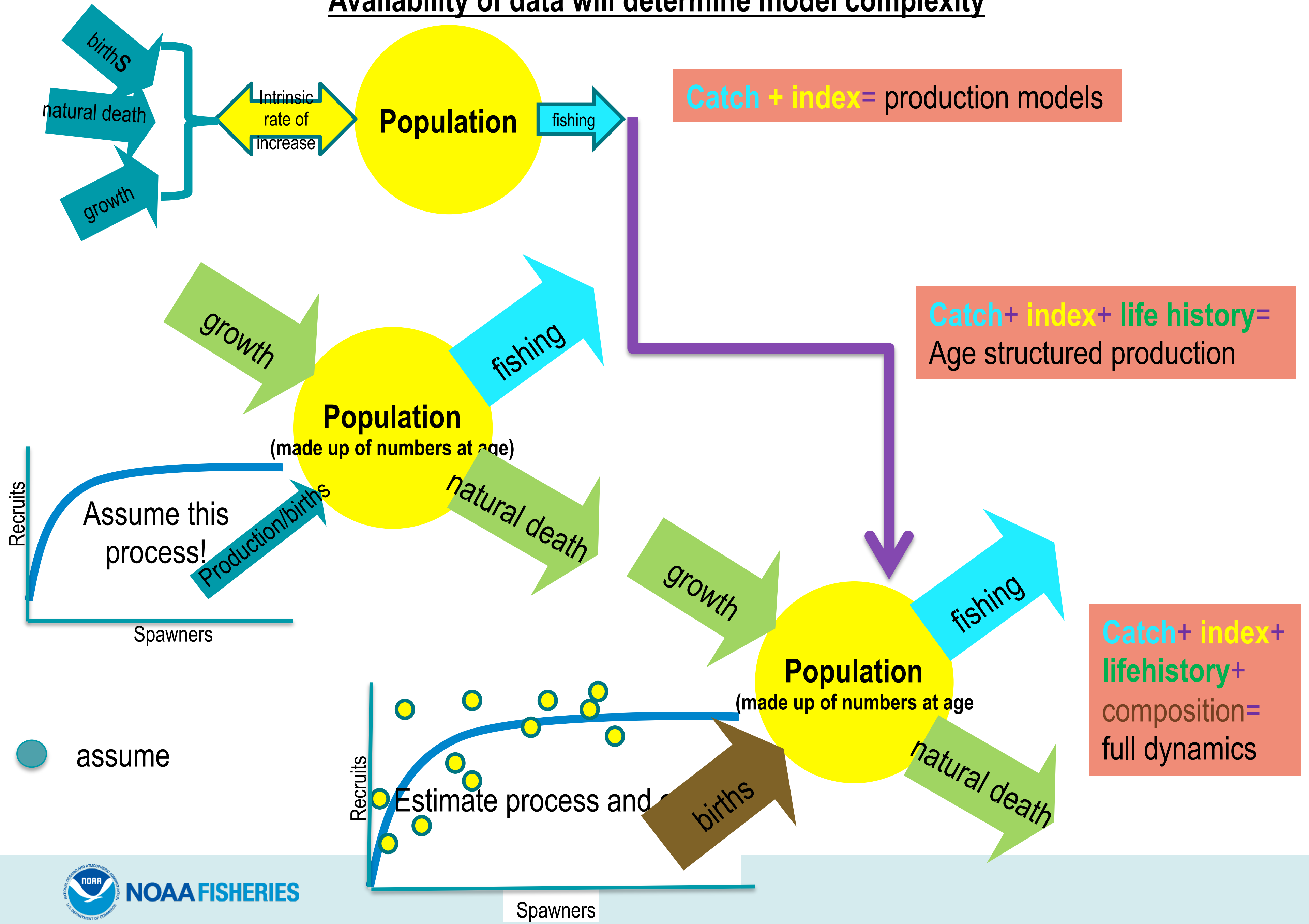
Large observation errors (due to sampling or analysis)

Almost no fishery independent information

Considerations in selecting a model

1. **Data richness**

Availability of data will determine model complexity



Assessment models by Taxonomic Groups

Rich

Data complexity

Minimal

Unknown

Tunas - Good catches, targeted species composition data, strong CPUE and complete life history

Age-structured models with full dynamics – SS (historically Multifan CL and VPA)

Billfishes - Reasonable catches, somewhat targeted species composition data, moderate CPUE and mostly complete life history

Models mostly age-structured models with full dynamics but with some biomass dynamics- primarily SS and BSP (some ASPIC)

Sharks - incomplete catches, somewhat targeted species some composition data, CPUE and generally incomplete life history

Biomass dynamics models and age-structured-production – SS and BSP (different code)

Others – problematic

fishery indicators?

Considerations in selecting a model

1. Data richness

2.User familiarity

Assessments conducted under ISC have different countries leading the modeling efforts. Working groups choose modeling approach but generally defer to the lead scientists wishes.

Generally leads to using more than one assessment model with different complexity.

Considerations in selecting a model

1. Data richness

2. user familiarity

3. Commonality of modeling platform –

There has been a concerted effort by US and IATTC to migrate assessments into SS.

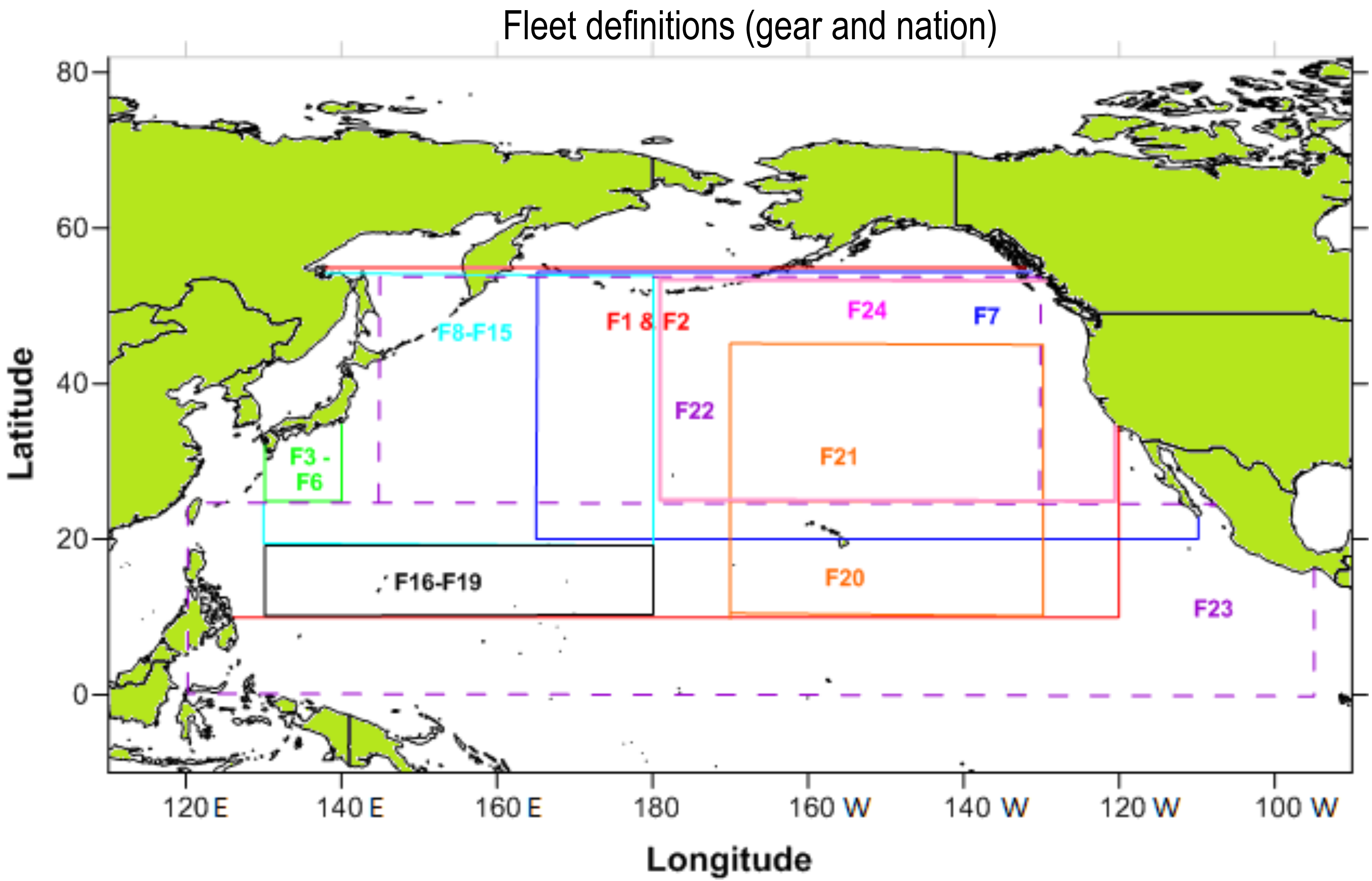
Flexibility of the model often provides a better representation of the data

Easier to share and review model within WG

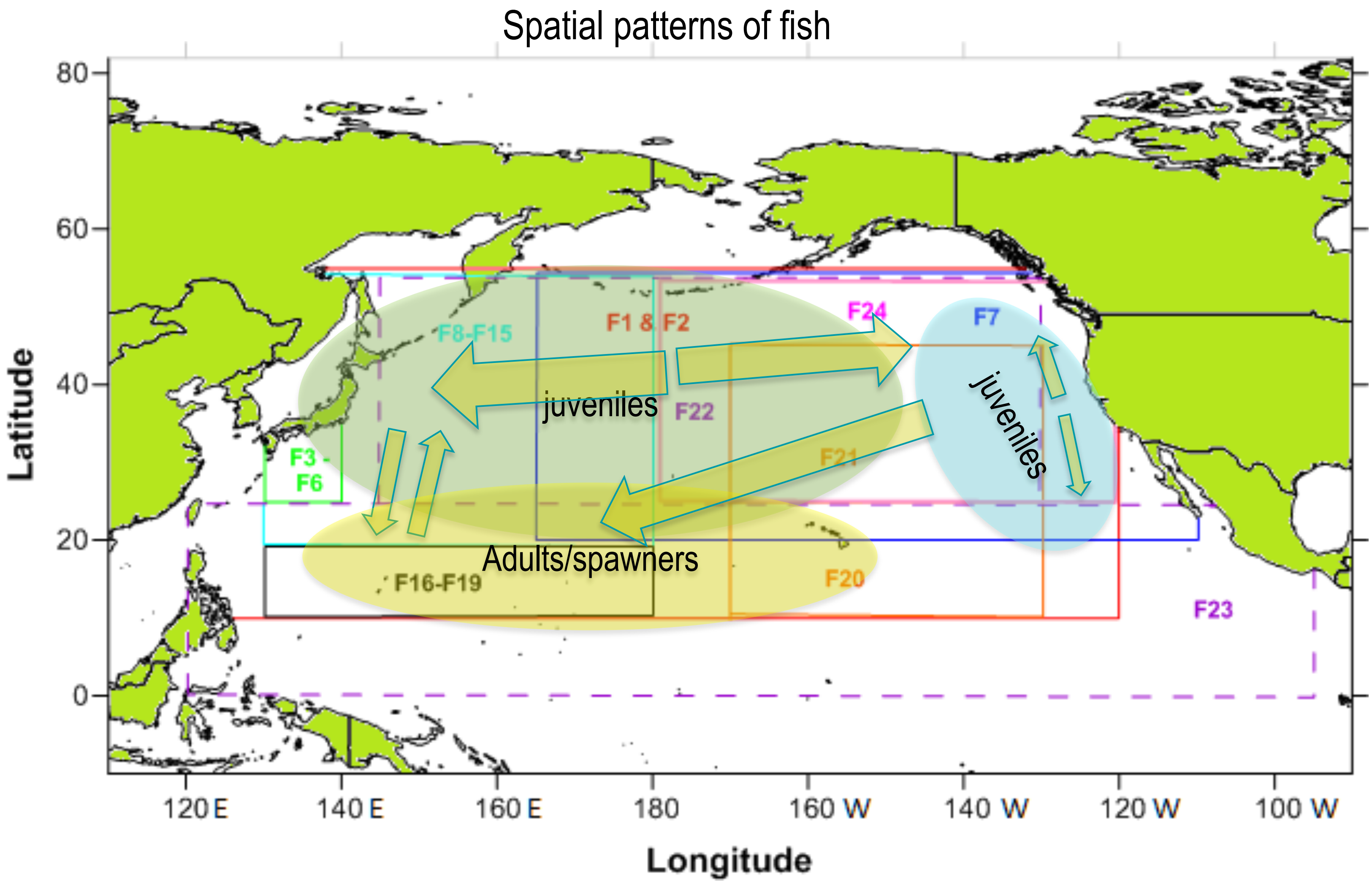
Capacity building

Amount of time devoted to model building versus data analysis

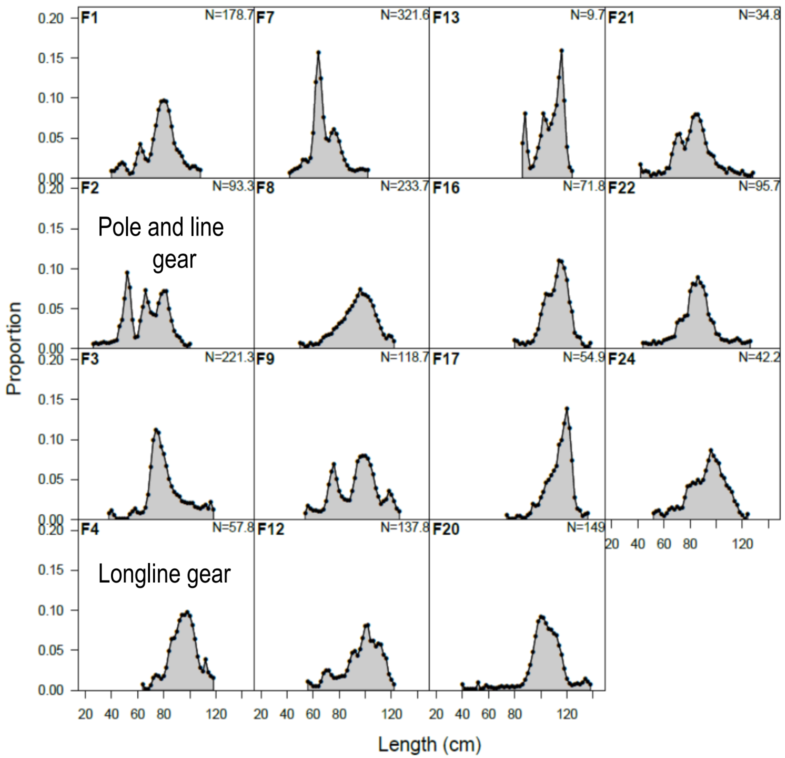
Example Data Rich: North Pacific Albacore Tuna

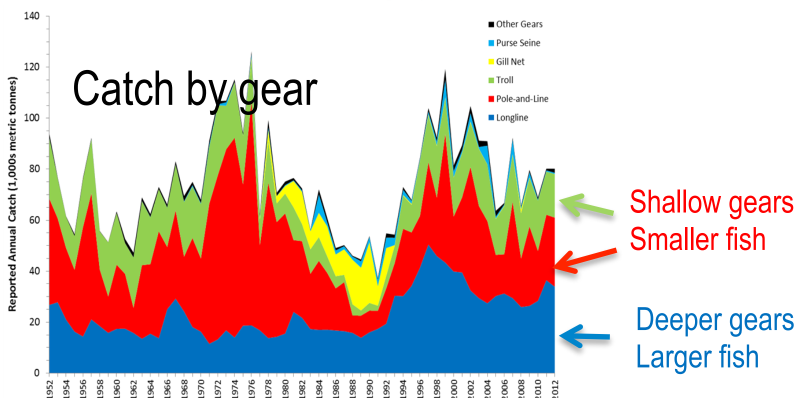


Example Data Rich: North Pacific Albacore Tuna

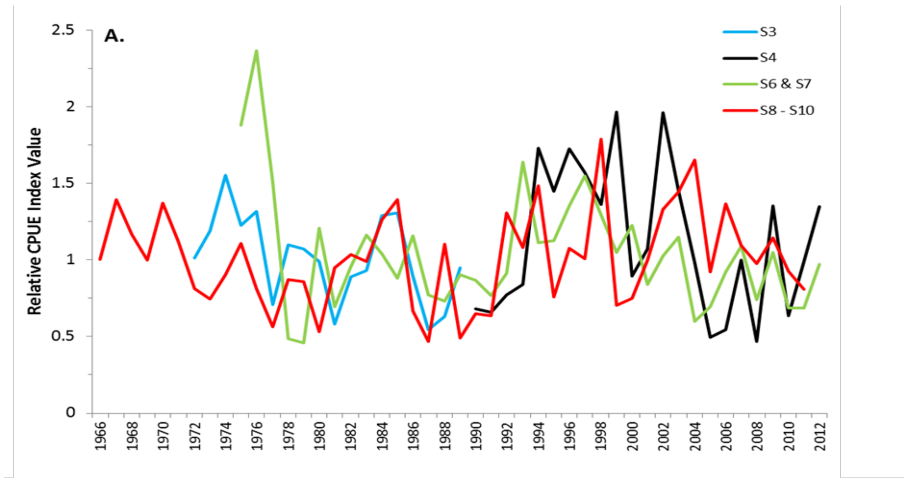


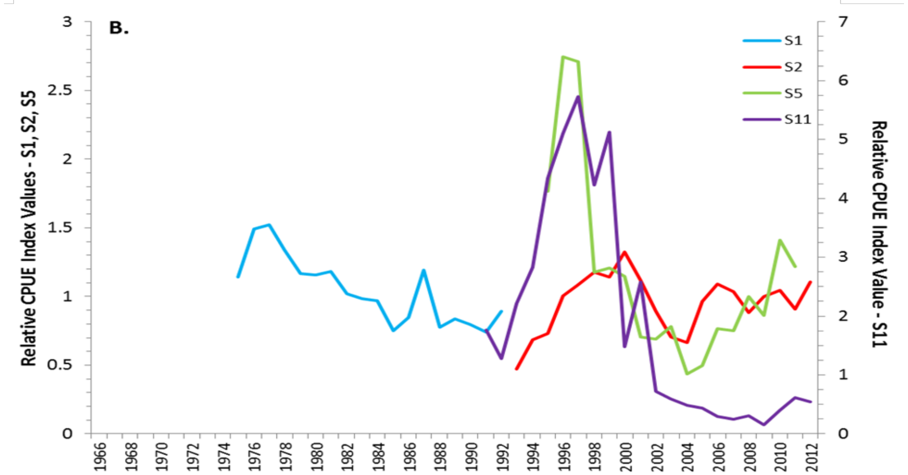
Size composition summarized across year/season by fleet



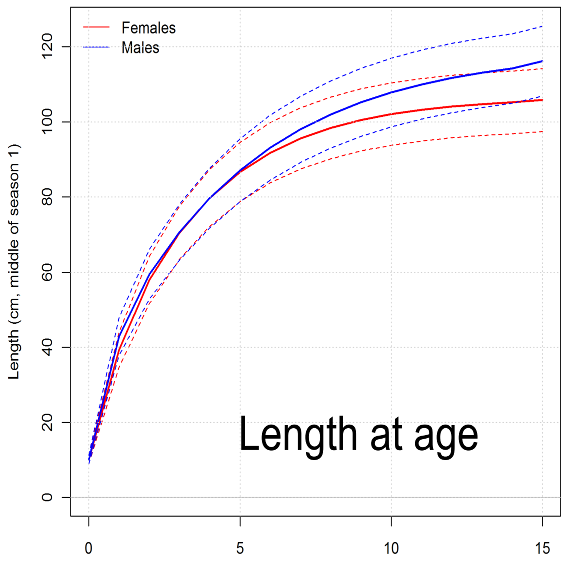


Indices of abundance from commercial CPUE





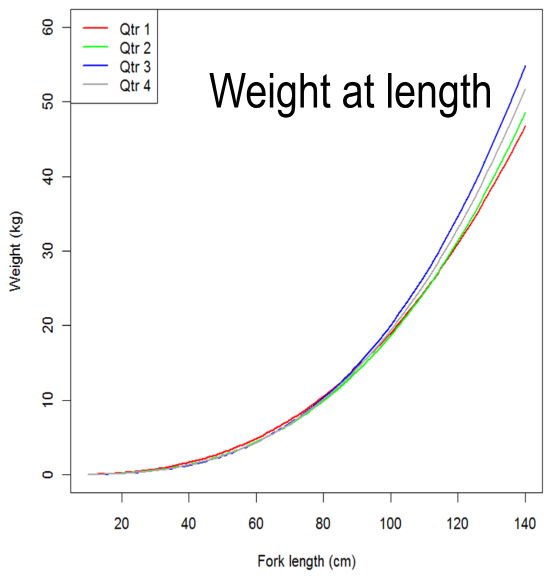
Life-history information

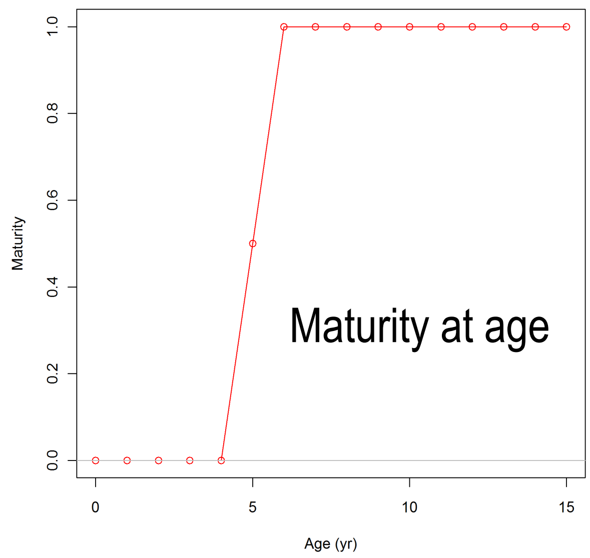


Full set of life-history information

Natural mortality?

$M=0.3yr^{-1}$





Assessment Model

Stock Synthesis- age structured with full dynamics

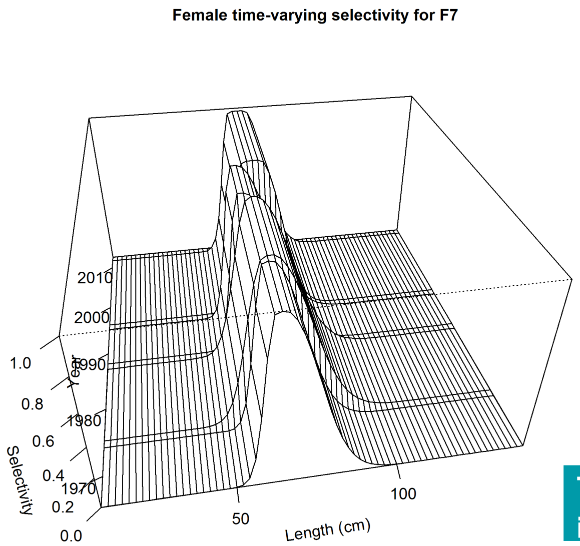
Important model structure included

Single area
Seasonal
Age and sex-structured
Regional fleet definitions (selection pattern estimated to account for spatial effects)
24 fleets (use fleet to account for seasonal changes in selectivity and spatial patterns)
Time varying selectivity (changes in fishing practices)
Few indices of abundance (essentially one adult and one juvenile)

Important model structure not included

Spatial dynamics (movement)
Sex-specific selection pattern (no composition by sex)

*Alternative production models

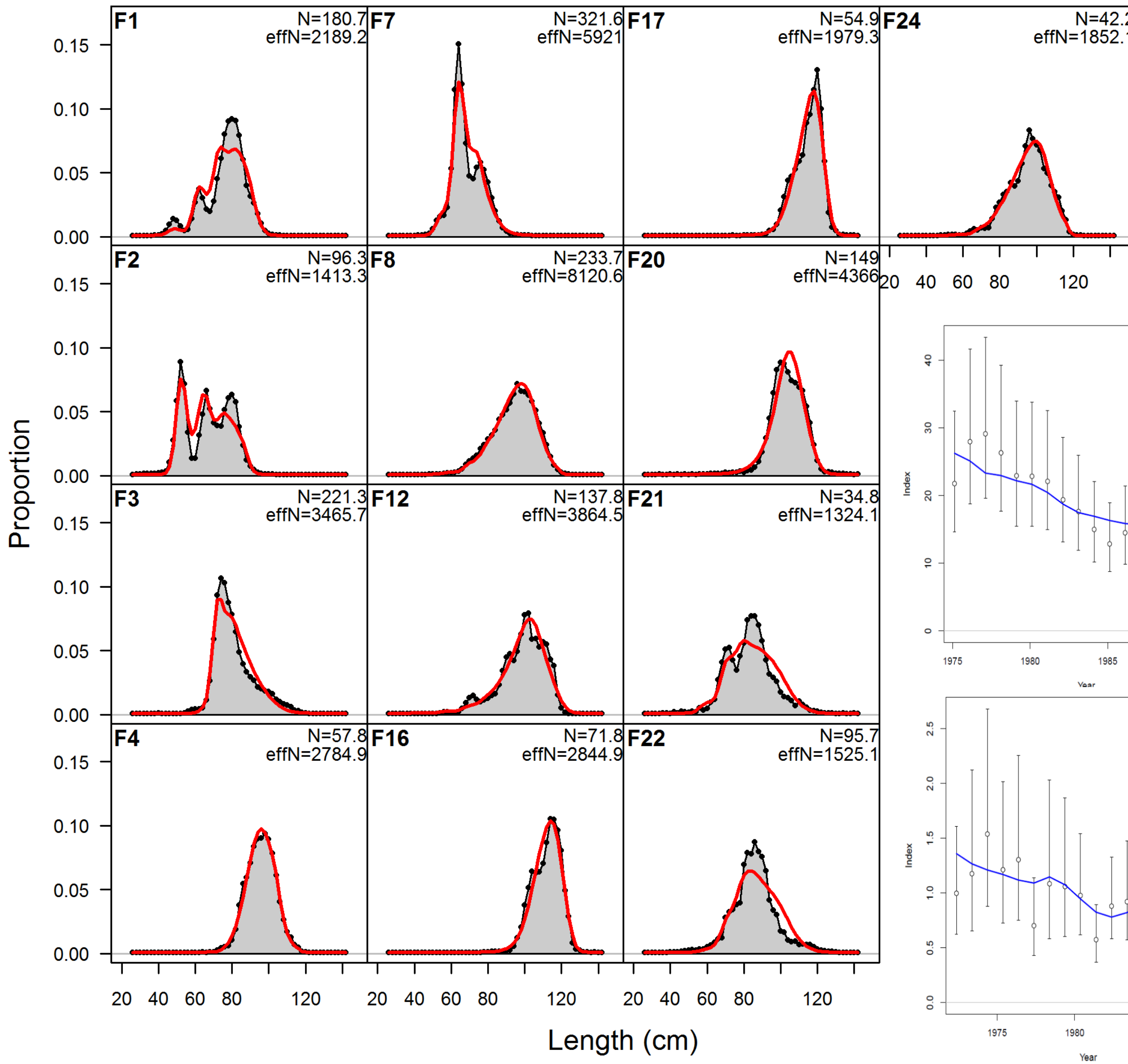


Model misfit handled with both additional model process and reduced data weights (observation error +process error) and strong assumptions (throw out data and assume the process needed)

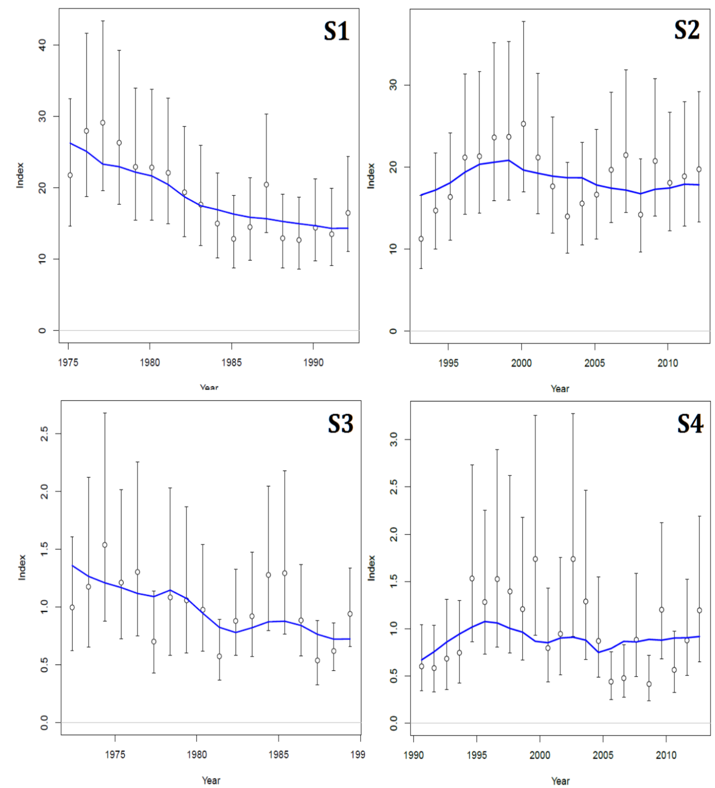
Table 4.4. Variance adjustment factors used in the base case model. Fisheries with neither abundance indices nor size composition data are not shown.

Fishery	Additional CV for indices	Multipliers on sample size for size composition data
F1 (S3)	0.0	0.03
F2 (S4)	0.1	0.03
F3	-	0.03
F4	-	0.03
F7	-	0.045
F8 (S1)	0.0	0.03
F9	-	0.03
F12 (S2)	0.0	0.03
F13	-	0.03
F16	-	0.06
F17	-	0.06
F20	-	0.06
F21	-	0.06
F22	-	0.06
F24	-	0.06

Model fit



* Note: originally 15 fleets with comp data now only 12 used in fitting



* Note: originally 11 CPUE series only 4 used in fitting

R0 Diagnostic

ln(R_0)	S3	S4	S2	S1	Sum
10.0	0.39	0.30	0.94	0.20	0.98
10.1	0.39	0.22	0.98	0.16	0.90
10.2	0.38	0.16	1.02	0.13	0.84
10.3	0.35	0.13	1.01	0.08	0.73
10.4	0.23	0.00	0.72	0.02	0.11
10.5	0.20	0.02	0.63	0.00	0.00
10.6	0.19	0.10	0.64	0.00	0.08
10.7	0.17	0.15	0.52	0.03	0.02
10.8	0.15	0.22	0.40	0.10	0.02
10.9	0.12	0.29	0.29	0.19	0.03
11.0	0.09	0.34	0.20	0.28	0.07
11.1	0.07	0.38	0.12	0.39	0.11
11.2	0.05	0.42	0.07	0.50	0.17
11.3	0.03	0.44	0.03	0.60	0.25
11.4	0.01	0.46	0.01	0.69	0.32
11.5	0.00	0.47	0.00	0.78	0.40

Colors indicate relative likelihood (green: low negative log-likelihood, better-fit; red: high negative log-likelihood, poorer-fit).

Little information on population scale
Coming from catch applied to index.

Not much info from composition data either

But what little info exists is relatively consistent

ln(R_0)	F1	F2	F3	F4	F7	F8	F12	F16	F17	F20	F21	F22	F24	Sum
10.0	1.26	1.11	1.38	0.17	0.00	0.57	0.1	0.33	1.24	0.22	0.00	0.00	0.52	2.19
10.1	1.22	1.06	1.38	0.14	0.08	0.36	0.06	0.29	1.15	0.11	0.01	0.07	0.47	1.70
10.2	1.19	1.01	1.38	0.11	0.16	0.16	0.03	0.26	1.06	0.05	0.01	0.14	0.43	1.29
10.3	1.16	0.95	1.38	0.09	0.24	0.00	0.01	0.21	0.97	0.03	0.03	0.21	0.39	0.98
10.4	1.06	0.85	1.19	0.08	0.30	0.40	0.00	0.14	0.81	0.09	0.07	0.33	0.35	0.99
10.5	0.97	0.76	1.03	0.06	0.39	0.27	0.01	0.12	0.69	0.10	0.12	0.51	0.32	0.64
10.6	0.80	0.64	0.76	0.04	0.48	0.01	0.05	0.08	0.60	0.09	0.19	0.77	0.34	0.16
10.7	0.67	0.53	0.53	0.02	0.57	0.01	0.06	0.06	0.44	0.07	0.32	1.13	0.30	0.00
10.8	0.53	0.41	0.32	0.01	0.66	0.02	0.08	0.05	0.32	0.03	0.48	1.58	0.26	0.06
10.9	0.37	0.30	0.15	0.01	0.75	0.11	0.11	0.02	0.23	0.01	0.67	2.11	0.24	0.37
11.0	0.23	0.20	0.05	0.00	0.83	0.20	0.13	0.00	0.17	0.00	0.86	2.64	0.22	0.83
11.1	0.15	0.14	0.00	0.00	0.89	0.23	0.14	0.01	0.12	0.01	1.03	3.12	0.17	1.33
11.2	0.10	0.09	0.00	0.00	0.94	0.25	0.15	0.03	0.08	0.02	1.19	3.55	0.12	1.82
11.3	0.06	0.05	0.01	0.00	0.99	0.27	0.16	0.05	0.05	0.03	1.33	3.92	0.07	2.28
11.4	0.03	0.02	0.04	0.00	1.02	0.29	0.16	0.07	0.02	0.04	1.45	4.24	0.03	2.71
11.5	0.00	0.00	0.07	0.00	1.06	0.31	0.17	0.08	0.00	0.06	1.55	4.51	0.00	3.10

Colors indicate relative likelihood (green: low negative log-likelihood, better-fit; red: high negative log-likelihood, poorer-fit).

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10.5	0.20	0.0			
10.6	0.19	0.1			
10.7	0.				
10.8	0.				
10.9	0.				
11.0	0.				
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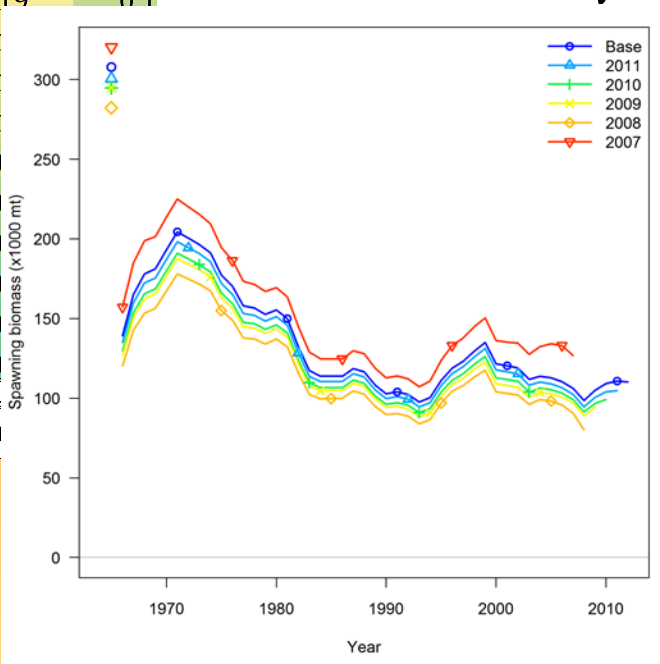
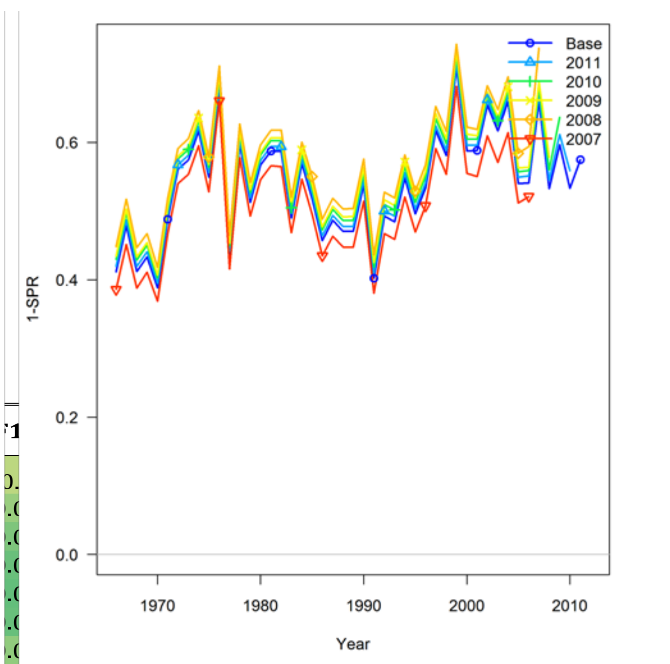
11.2	0.				
11.3	0.				
11.4	0.				
11.5	0.				

Colors indicate r
likelihood, bette

RETROSPECTIVE Analysis





ex.

data either

ely consistent

$\ln(R_0)$													24	Sum
10.0	1												52	2.19
10.1	1												47	1.70
10.2	1												43	1.29
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10.4	1												35	0.99
10.5	0												32	0.64
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10.8	0.53	0.41	0.32	0.01	0.66	0.02	0.08	0.05	0.32	0.03	0.48	1.58	0.26	0.06
10.9	0.37	0.30	0.15	0.01	0.75	0.11	0.11	0.02	0.23	0.01	0.67	2.11	0.24	0.37
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11.1	0.15	0.14	0.00	0.00	0.89	0.23	0.14	0.01	0.12	0.01	1.03	3.12	0.17	1.33
11.2	0.10	0.09	0.00	0.00	0.94	0.25	0.15	0.03	0.08	0.02	1.19	3.55	0.12	1.82
11.3	0.06	0.05	0.01	0.00	0.99	0.27	0.16	0.05	0.05	0.03	1.33	3.92	0.07	2.28
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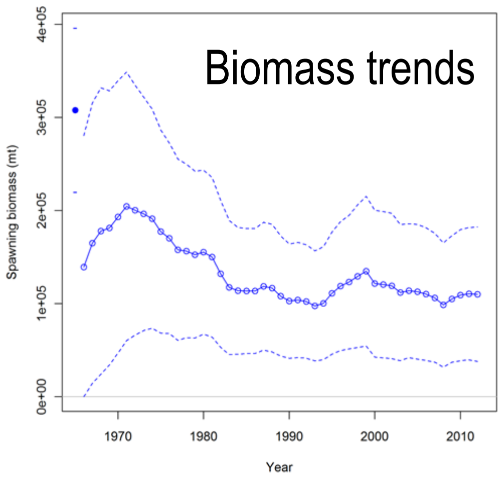
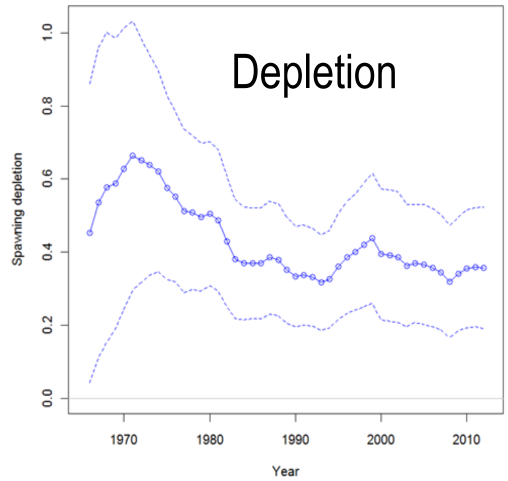
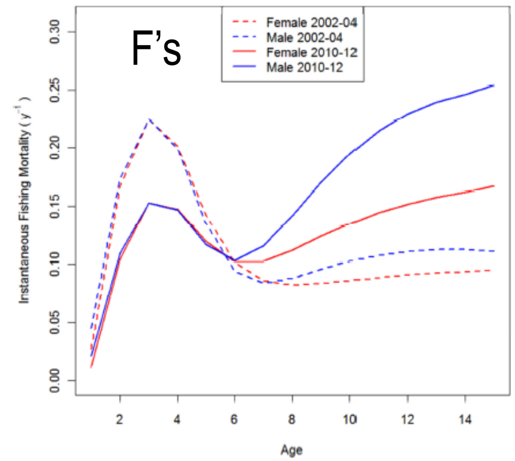
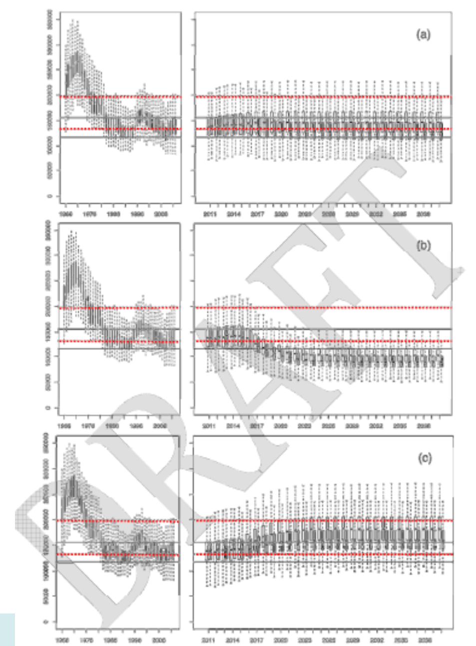
Results of age-structured model



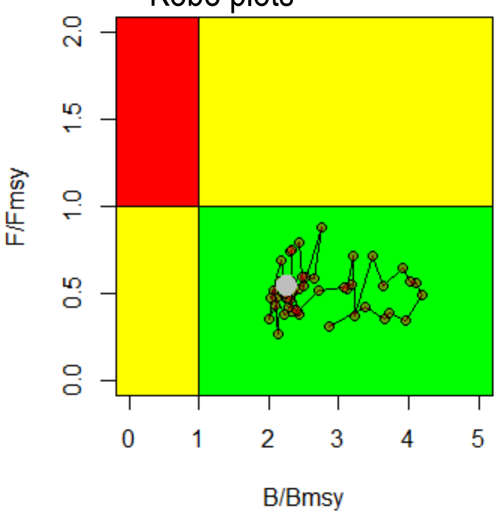




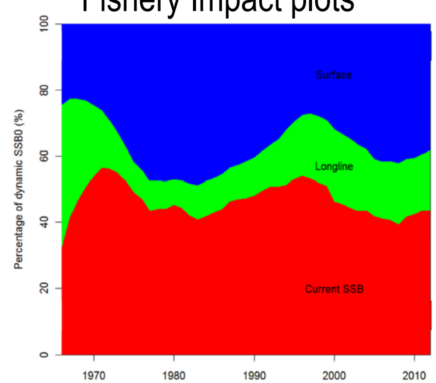
Stochastic projects under different recruitment conditions



Kobe plots



Fishery Impact plots



Example data moderate: N.P. swordfish

Uncertainty in Stock Structure and basic lifehistory

Stock Scenario - 1

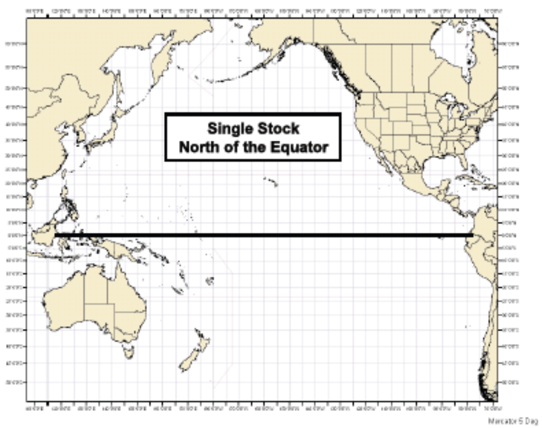
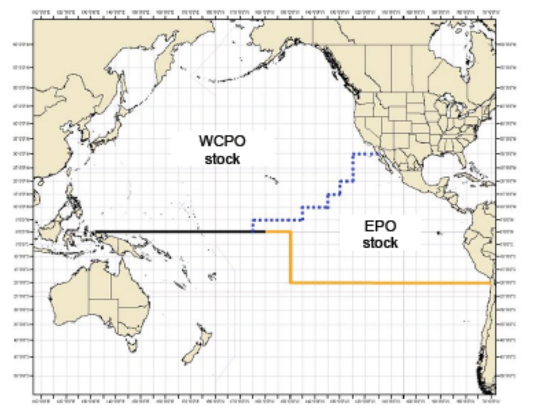


Figure 3. Stock Scenario-1, a single North Pacific swordfish stock north of the equator.

Stock Scenario - 2



...... Proposed boundary
Adapted from Ichinokawa and Brodziak (2008; Figure 7d)

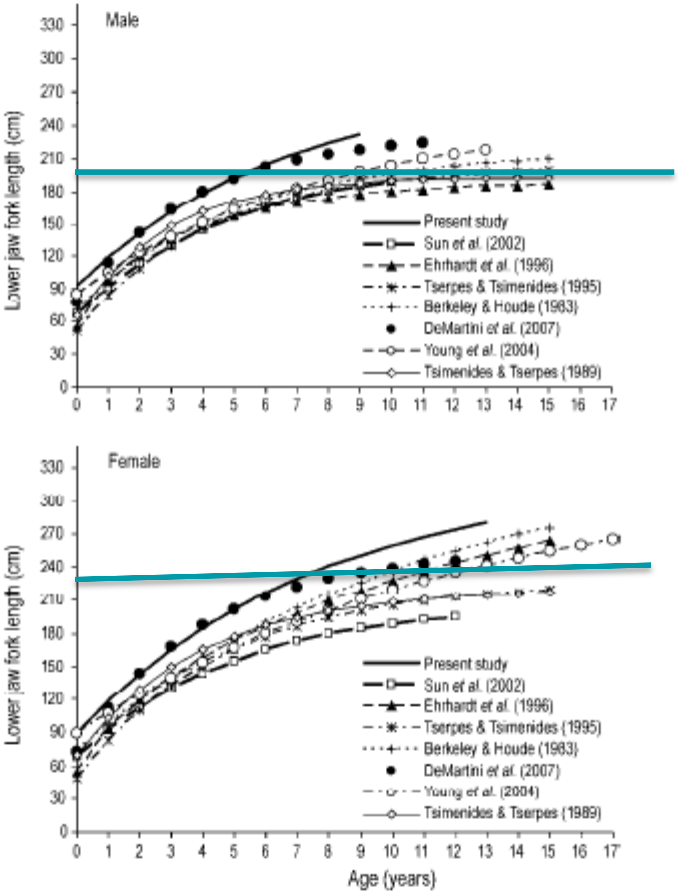


Figure 8. Sumary of Von Bertalanffy growth curves of swordfish estimated by different studies.

Cerna Lat. Am. J. Aquat. Res., 37(1): 59-69, 2009

Data:

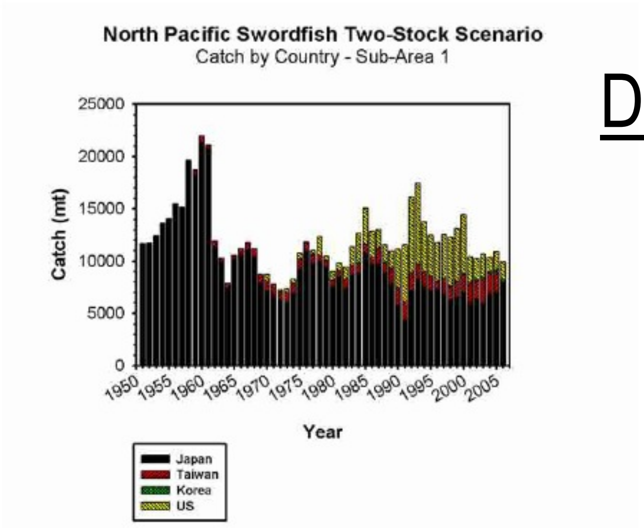


Figure 4. Total Sub-Area 1 swordfish catch by country under Stock Scenario-2, two North Pacific stocks.

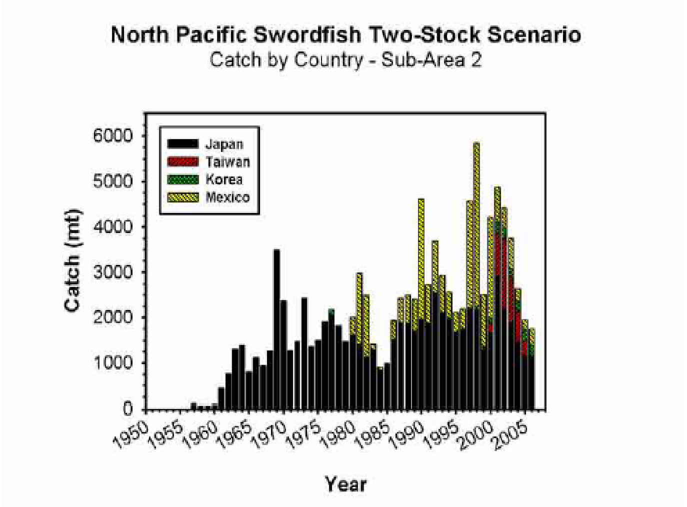
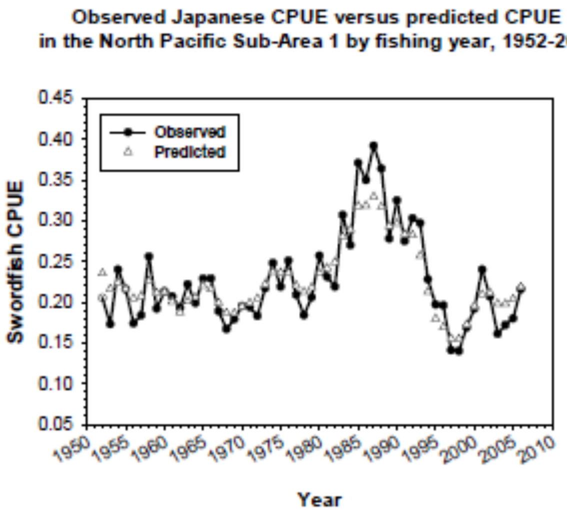
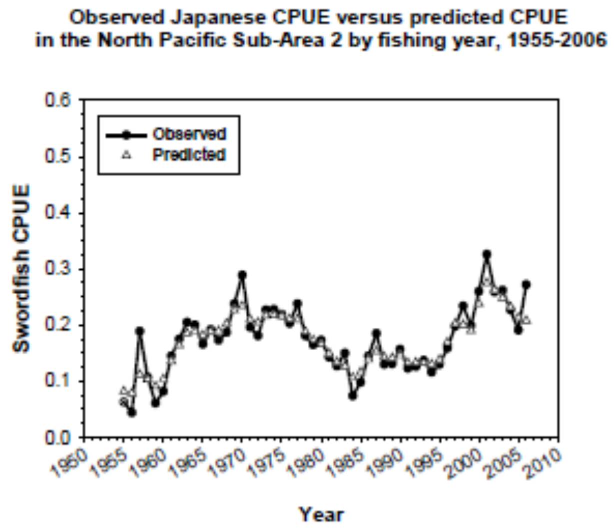


Figure 5. Total Sub-Area 2 swordfish catch by country under Stock Scenario-2, two North Pacific stocks.





Modeling

Considerable uncertainty in lifehistory
Limited composition data

User familiarity with model

Decision: Bayesian Production Model (biomass dynamics with limited model process)

Alternative age-structured model

Results

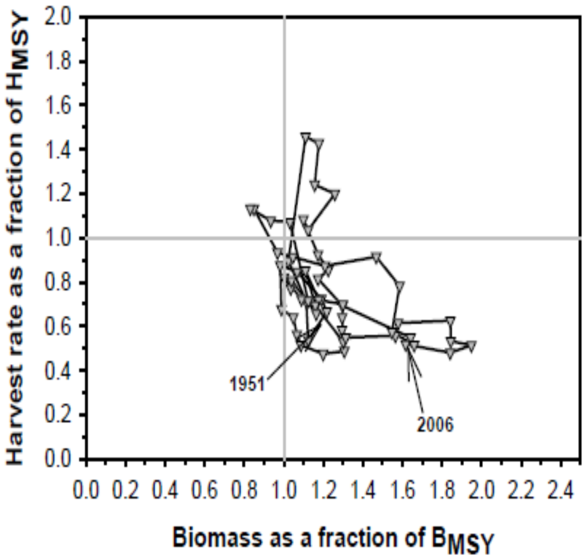


Figure 12. Sub-Area 1 biomass as a fraction of B_{MSY} and harvest rate as a fraction of H_{MSY} (19
– 2006).

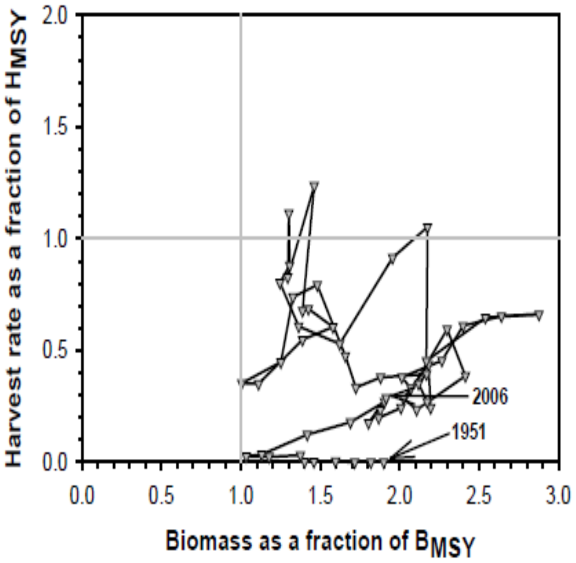


Figure 13. Sub-Area 2 biomass as a fraction of B_{MSY} and harvest rate as a fraction of H_{MSY} (1951
– 2006).

But wait

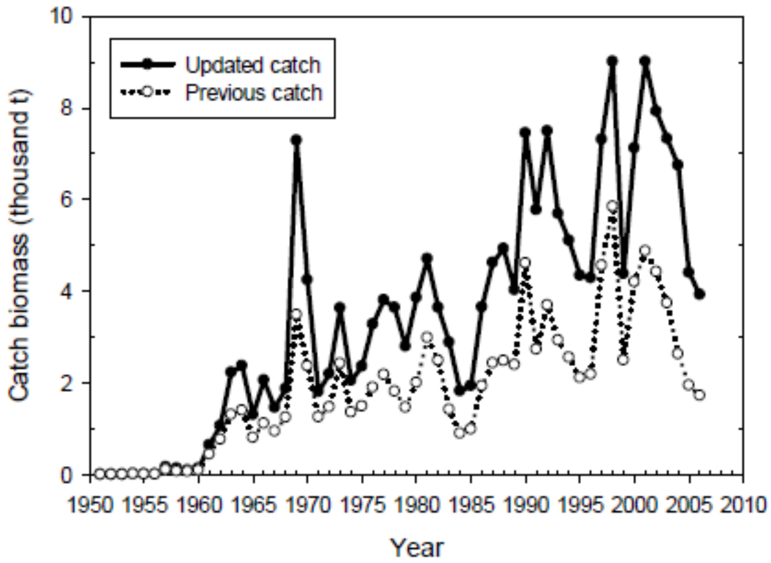
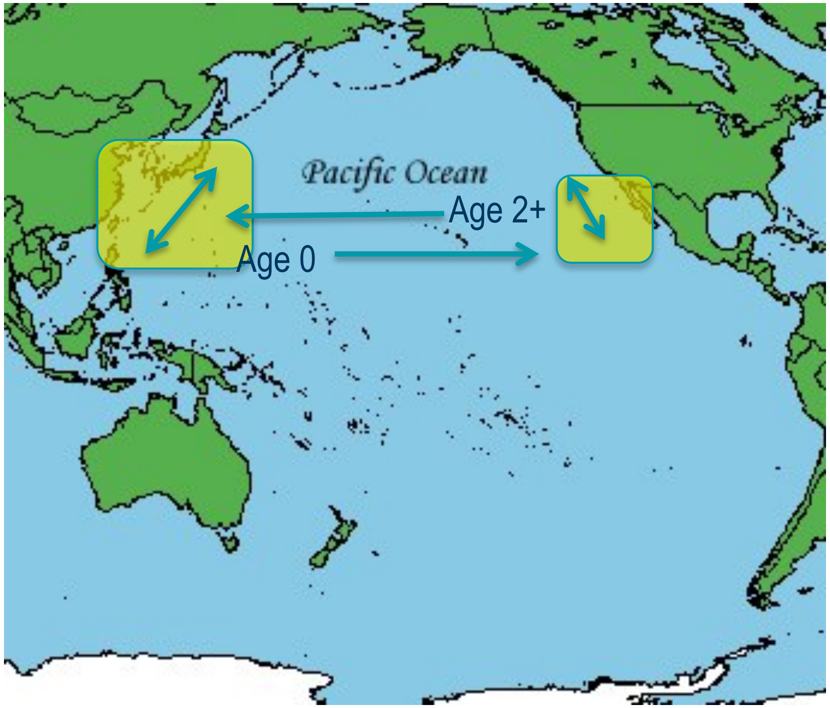


Figure 3. Total catch biomass estimates for the Eastern North Pacific (EPO) swordfish stock from 1952-2006. The updated catch biomass (solid line, filled circle) shows the catch used in the 2010 update of the EPO stock assessment reported at ISC 10. The previous catch biomass (dotted line, open circle) shows the catch used in the previous EPO stock assessment reported at ISC 9 in 2009.

Modeling Issues (where to start)

Poor/incomplete data/understanding makes it difficult to balance the complexity of the real biological/fisheries processes with the simplicity implied by the available data and/or our understanding of data.

*Available model structure has generally not been a hindrance to assessments.



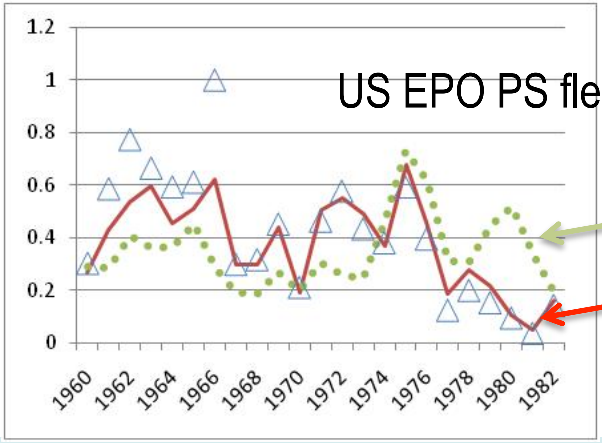
Movement (a missing process) :

HMS move by life stage (Pacific Bluefin tuna)

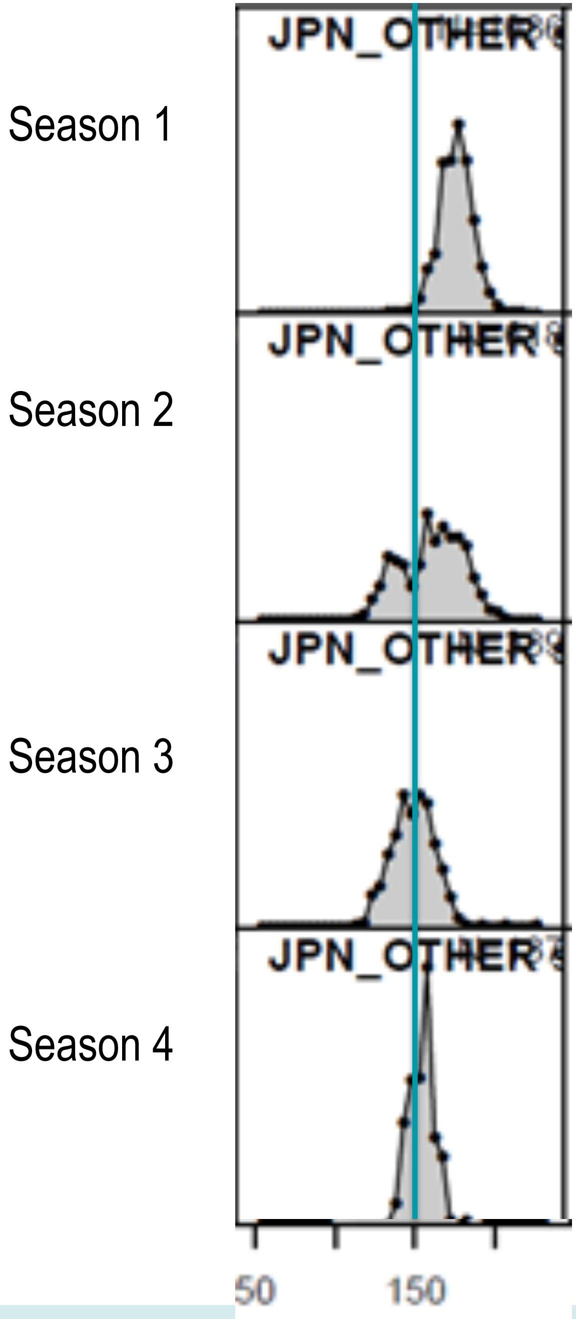
Introducing movement into the modelling has only been done on a "research" basis. No large scale tagging data available to inform movement.

Typically use *wrong* model process (regional) selectivity patterns to account for some spatial effects

Pacific Bluefin tuna



With movement modeled



Movement (a type of missing data) :

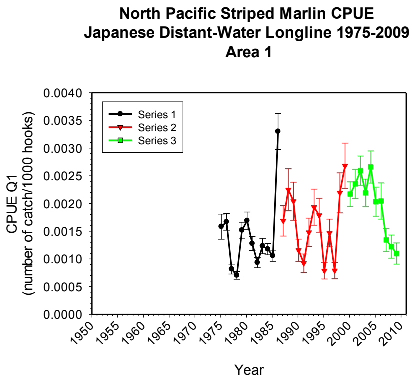
HMS move by life stage (Pacific Bluefin tuna)
But they also show semi-consistent seasonal movements.

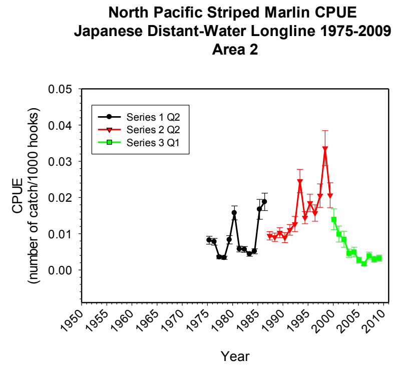
Introducing movement into the modelling has only been done on a "research" basis. No large scale tagging data available to inform movement.

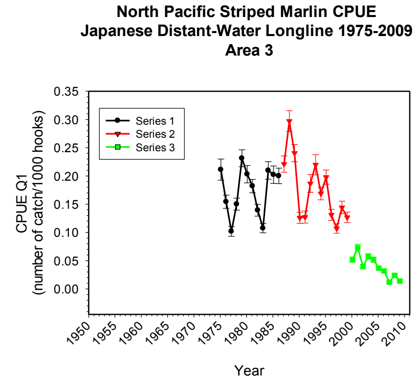
Typically use *complicated* model process (seasonal fleet def.) to account for spatial effects

Striped Marlin off Japan

Regional abundance trends that differ







Spatial modeling-requires movement

Data issue: Are some indices not plausible?

Separate models that have different trends- different results, requires subject choice of plausibility of trend. Avoid tossing everything into the model and hoping for the best.

Aggregate data across regions- might require weightings and often involves adding more model process to account for changes in the regional effort causing time varying model processes

Improve Modeling

Better data

Capacity building-Improve analysis to produce data streams.
Better data snooping and definition of fisheries catch weightings for comps, improved standardization of CPUE.
Improved assessment modeling

Move overly simple modes towards more complex modeling as data improves.

Increased use of simulation modeling to help guide choice of model structure

Improvement in model diagnostics to diagnose model mis-specification

Start thinking about how to handle the really data poor species.

Work to Improve Assessment Modeling

Alternative modeling methods

MacCall, Alec D., and **S. L.H. Teo**. (2013). A hybrid stock synthesis - Virtual population analysis model of Pacific bluefin tuna. Fisheries Research 142:22-26.

Model specification and parameter estimation

Lee, H.H., M. N. Maunder, **K. R. Piner**, and R. D. Methot (2012). Can steepness of the stock-recruitment relationship be estimated in fishery stock assessment models? *Fish. Res. (125-126):254-261.*

Lee, H.H., M.N. Maunder**, K.R. Piner**, R. D. Methot (2011). Estimating natural mortality within a fisheries stock assessment model: an evaluation using simulation analysis based on twelve stock assessments. *Fish. Res.* 109:89-94

Model diagnostics and structuring methods

Maunder, M.N. and **K. R. Piner**. (In Press). Contemporary fisheries stock assessment: many issues still remain. ICES Journal of Marine Science.

Wang, S.P., M.N., Maunder**, K.R., Piner**, A. Aires-da-Silva, and H.H., Lee. (*2014*). Evaluation of virgin recruitment profiling as a diagnostic for selectivity curve structure in integrated stock assessment models. *Fish Res*. 158:158-164.

Lee, H.H**., K.R., Piner**, R.D., Methot, Jr., and M.N., Maunder (*2014*). Use of likelihood profiling over a global scaling parameter to structure the population dynamics model: an example using blue marlin in the Pacific Ocean. *Fish.Res.*158:138-146*.*

Piner, K.R., H.H Lee,.M. N. Maunder, and R. D. Methot. (2011). A simulation-based method to determine model misspecificaton: Examples using natural mortality and population dynamics models. *Mar. Coast. Fish*.3:336-343.

Theme I:
Scientific/technical approach to fishery stock assessment modeling

Is the Center using an appropriate suite of analytical methods to meet the regional fishery stock assessment objectives?

Does the suite of assessment models cover considerations from data-poor to data rich?

Are assessments capable of considering possible ecosystem effects?

Does the Center work on enhancing and testing these analytical methods? Are they keeping with and contributing to the state-of-the-science nationally and internationally?

Strengths

Technical expertise to bring to international settings
Can rely on the experience of domestic groups to improve both the science and process
Independence (best science)

Challenges

Limited quality data and complexity of situation puts scientists in a tough box
No access to majority of data
Time demands for assessment, RFMO/Council committees, overhead are eating away from:
ability to improve future assessments
ability to conduct simulation, MSE analysis needed

Strategies

Improve capabilities of other member countries
Reduce # meetings (explore web meetings)
Encourage data sharing (of course that will increase the workload)
Use more simulation analyses to improve assessments and develop BRPs